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Stouder-Studenmund

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(54) **DEVICE CENTRIC OR INTERACTIVE DISCOVERY**

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H04W 4/00 (2009.01)
H04L 29/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H04W 8/005*** (2013.01); ***H04L 67/14*** (2013.01); ***H04W 4/008*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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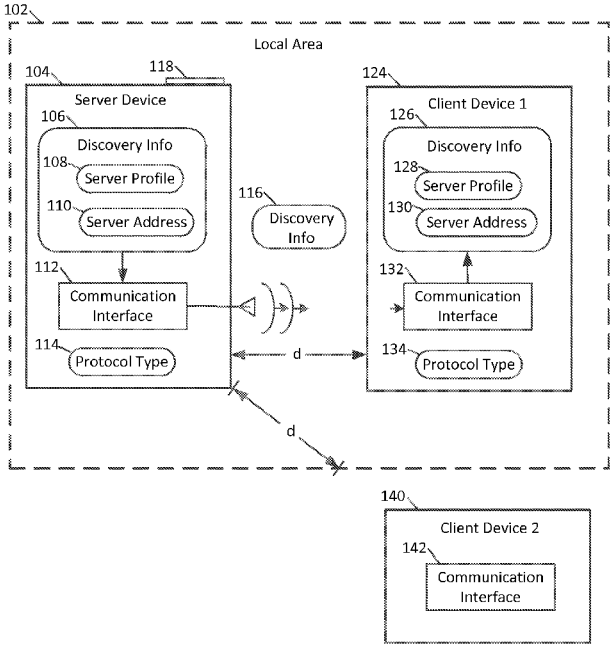
(57) **ABSTRACT**

Methods and apparatus are provided for discovering computing devices in a local area. A method includes receiving, by a first device, a request to provide discovery information, generating, by the first device, the discovery information, wherein the discovery information includes a communication address of the first device, and providing, by the first device, the discovery information using a short-range protocol that can be received only within a defined distance of the first device. The method can further include receiving, by a second device, the discovery information, wherein the second device is located within the defined distance of the first device, extracting, by the second device, the communication address of the first device from the discovery information, and initiating, by the second device, communication with the first device using the communication address and a communication protocol associated with the address.

20 Claims, 8 Drawing Sheets



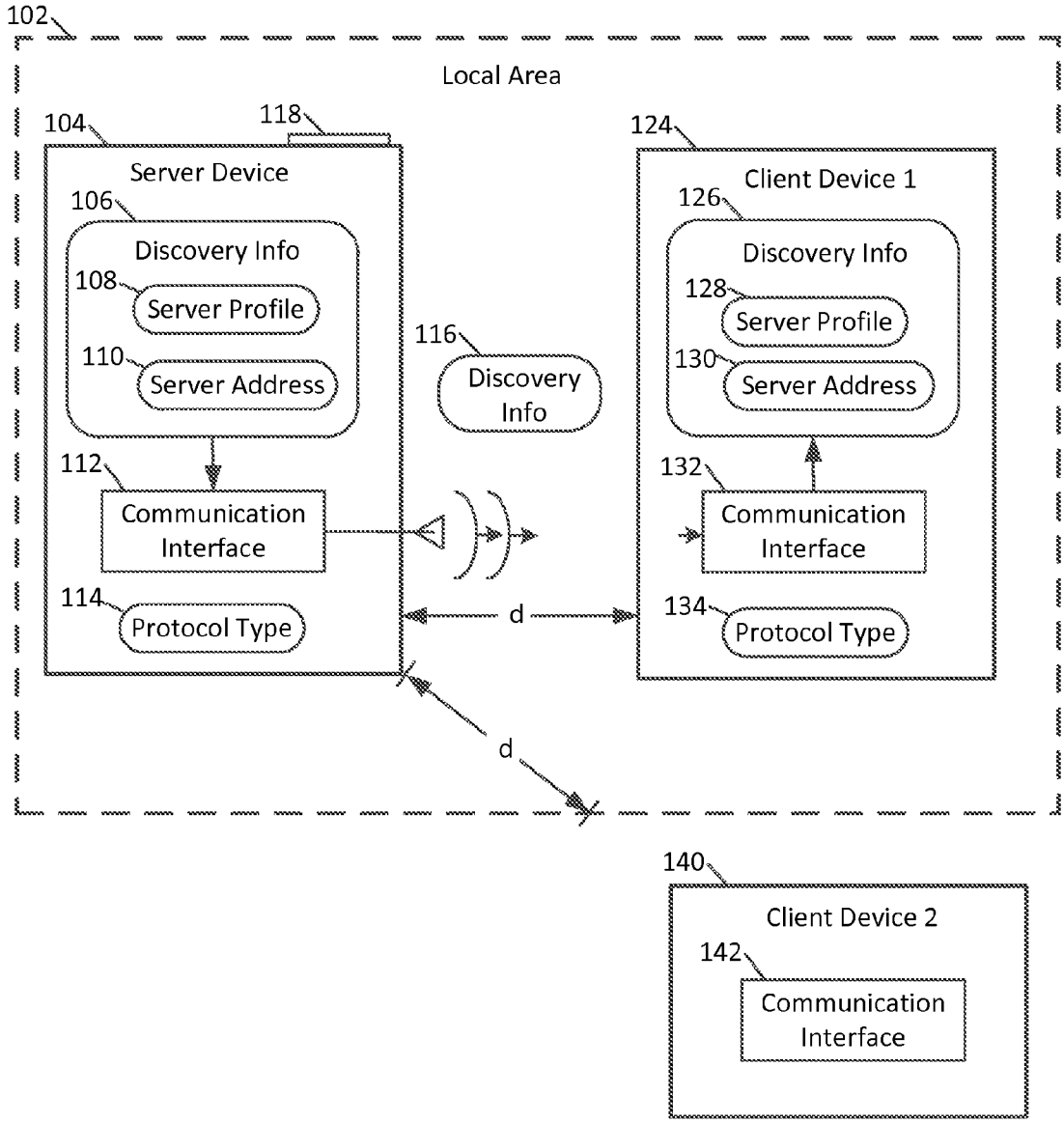

102
Local Area
104
118
Server Device
106
Discovery Info
108
Server Profile
110
Server Address
112
Communication Interface
114
Protocol Type
116
Discovery Info
124
Client Device 1
126
Discovery Info
128
Server Profile
130
Server Address
132
Communication Interface
134
Protocol Type
d
d
140
Client Device 2
142
Communication Interface

FIG. 1

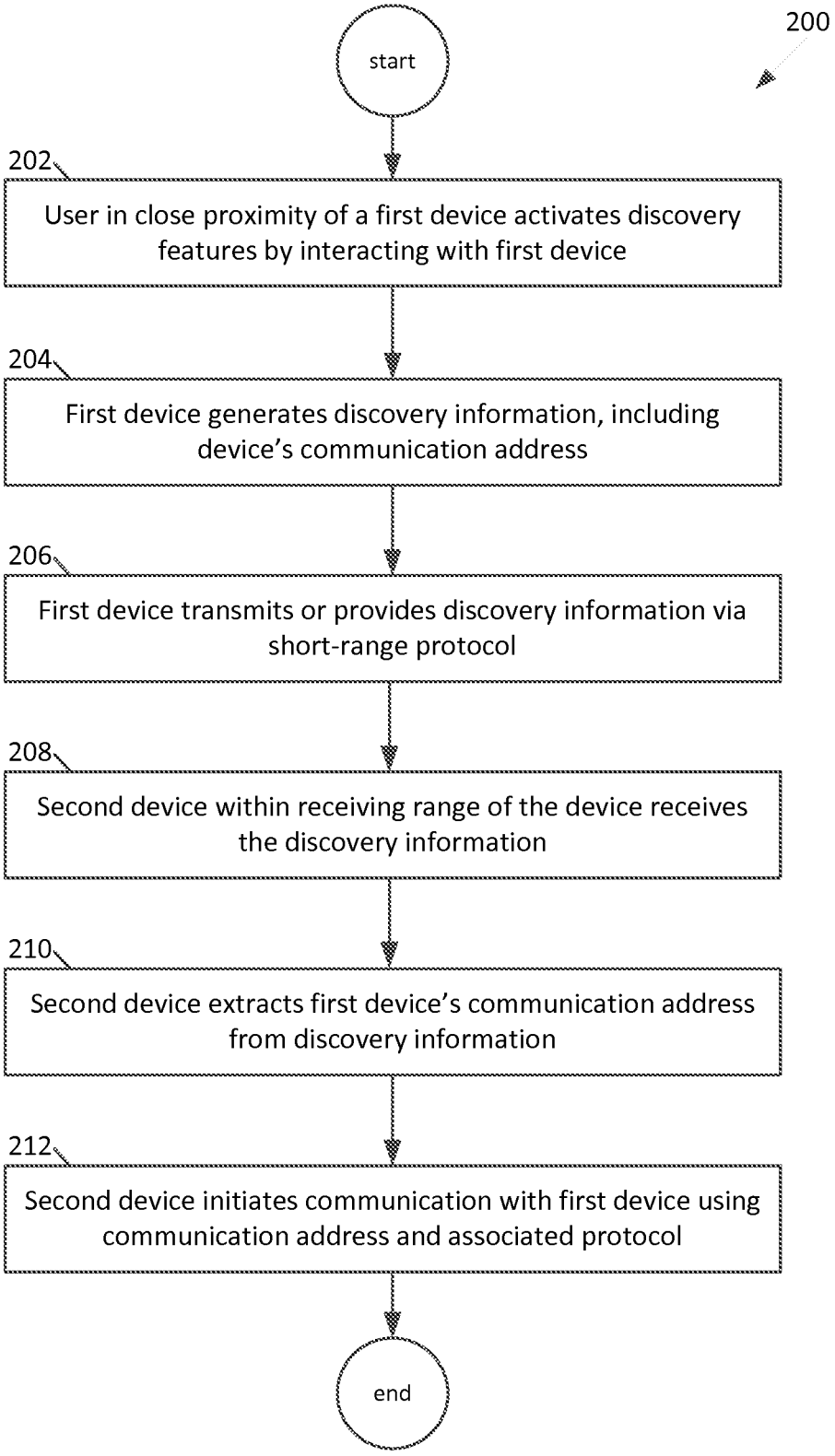

200
start
202
User in close proximity of a first device activates discovery features by interacting with first device
204
First device generates discovery information, including device's communication address
206
First device transmits or provides discovery information via short-range protocol
208
Second device within receiving range of the device receives the discovery information
210
Second device extracts first device's communication address from discovery information
212
Second device initiates communication with first device using communication address and associated protocol
end

FIG. 2

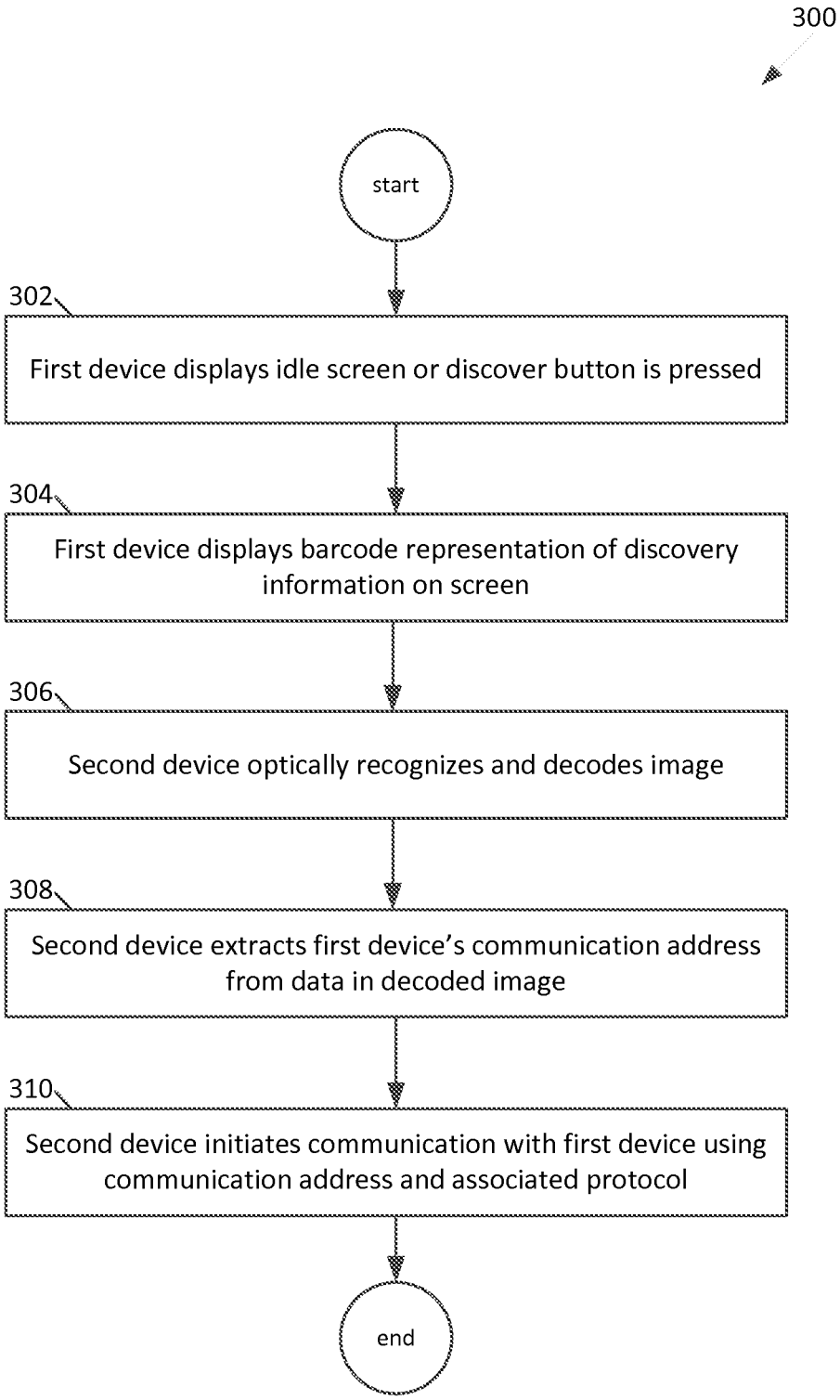

300
start
302
First device displays idle screen or discover button is pressed
304
First device displays barcode representation of discovery information on screen
306
Second device optically recognizes and decodes image
308
Second device extracts first device's communication address from data in decoded image
310
Second device initiates communication with first device using communication address and associated protocol
end

FIG. 3

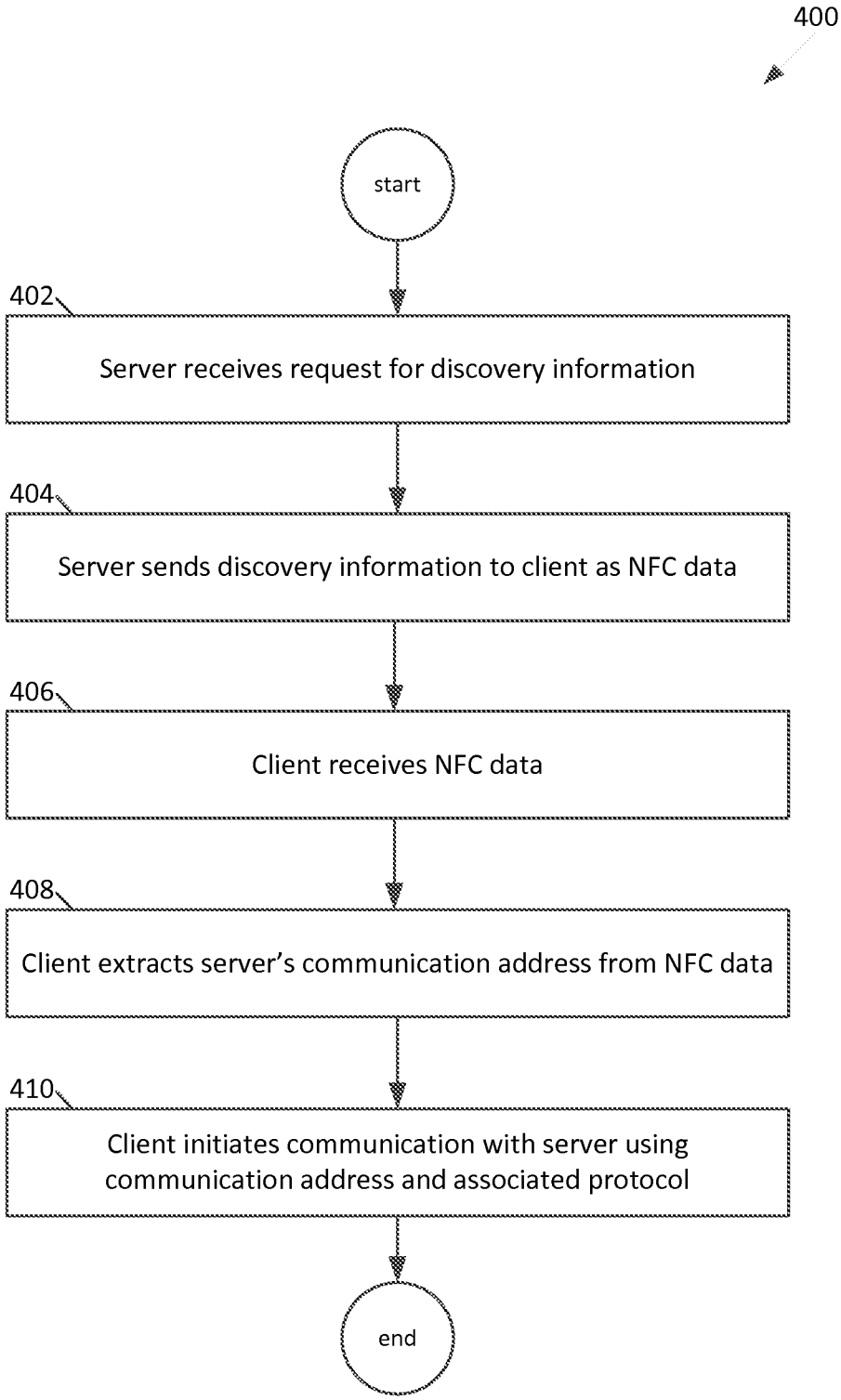

400
start
402
Server receives request for discovery information
404
Server sends discovery information to client as NFC data
406
Client receives NFC data
408
Client extracts server's communication address from NFC data
410
Client initiates communication with server using communication address and associated protocol
end

FIG. 4

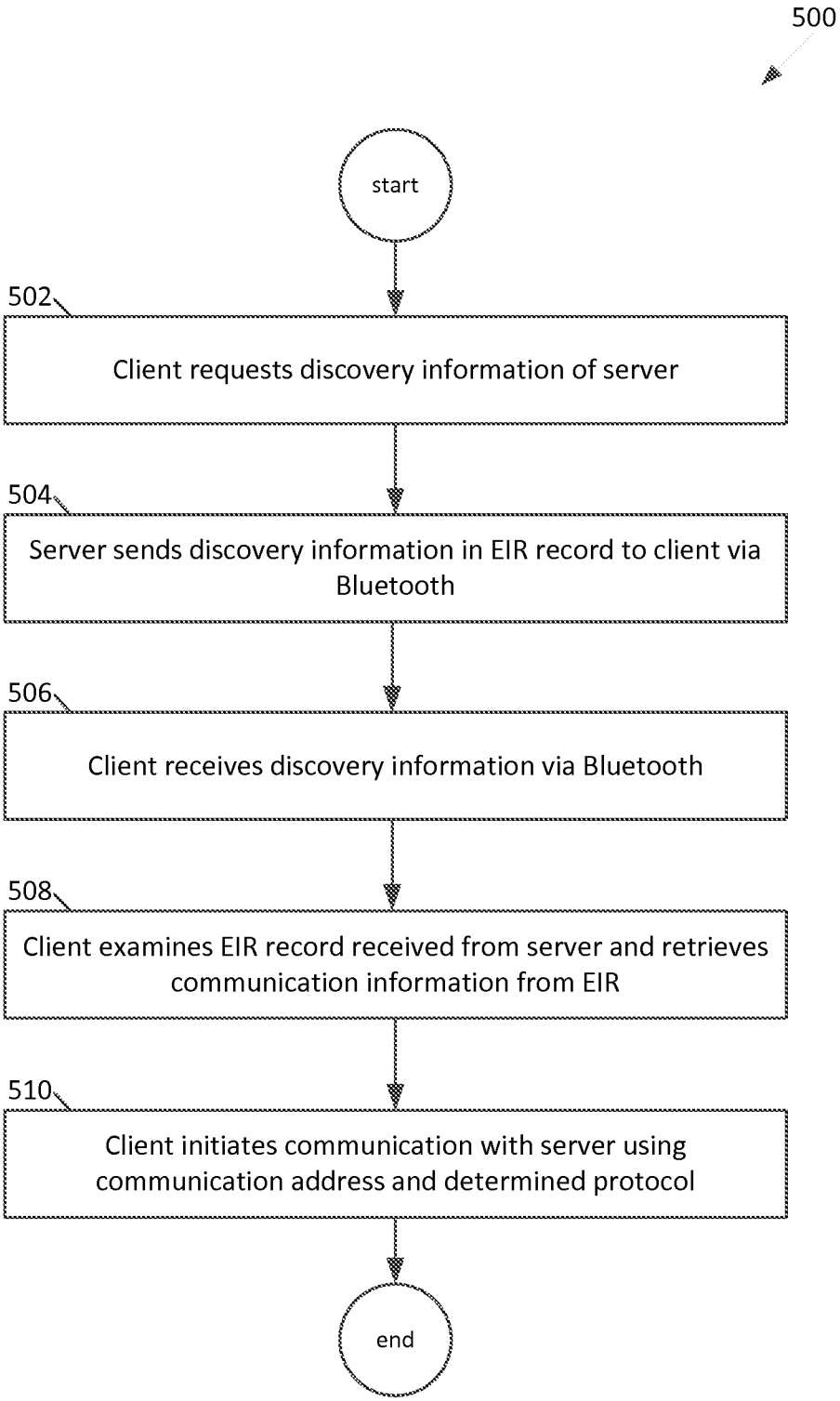

500
start
502
Client requests discovery information of server
504
Server sends discovery information in EIR record to client via Bluetooth
506
Client receives discovery information via Bluetooth
508
Client examines EIR record received from server and retrieves communication information from EIR
510
Client initiates communication with server using communication address and determined protocol
end

FIG. 5

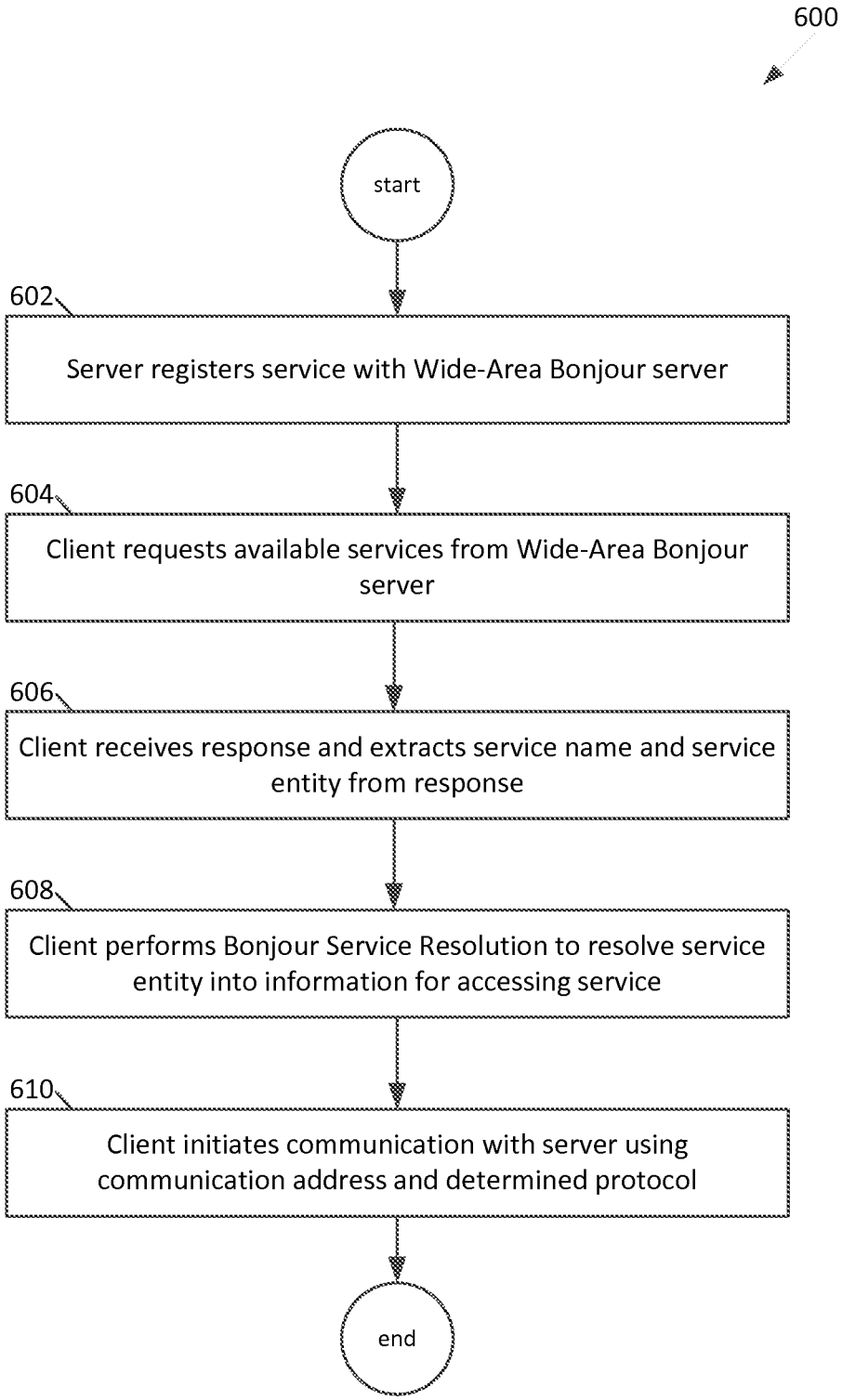

600
start
602
Server registers service with Wide-Area Bonjour server
604
Client requests available services from Wide-Area Bonjour server
606
Client receives response and extracts service name and service entity from response
608
Client performs Bonjour Service Resolution to resolve service entity into information for accessing service
610
Client initiates communication with server using communication address and determined protocol
end

FIG. 6

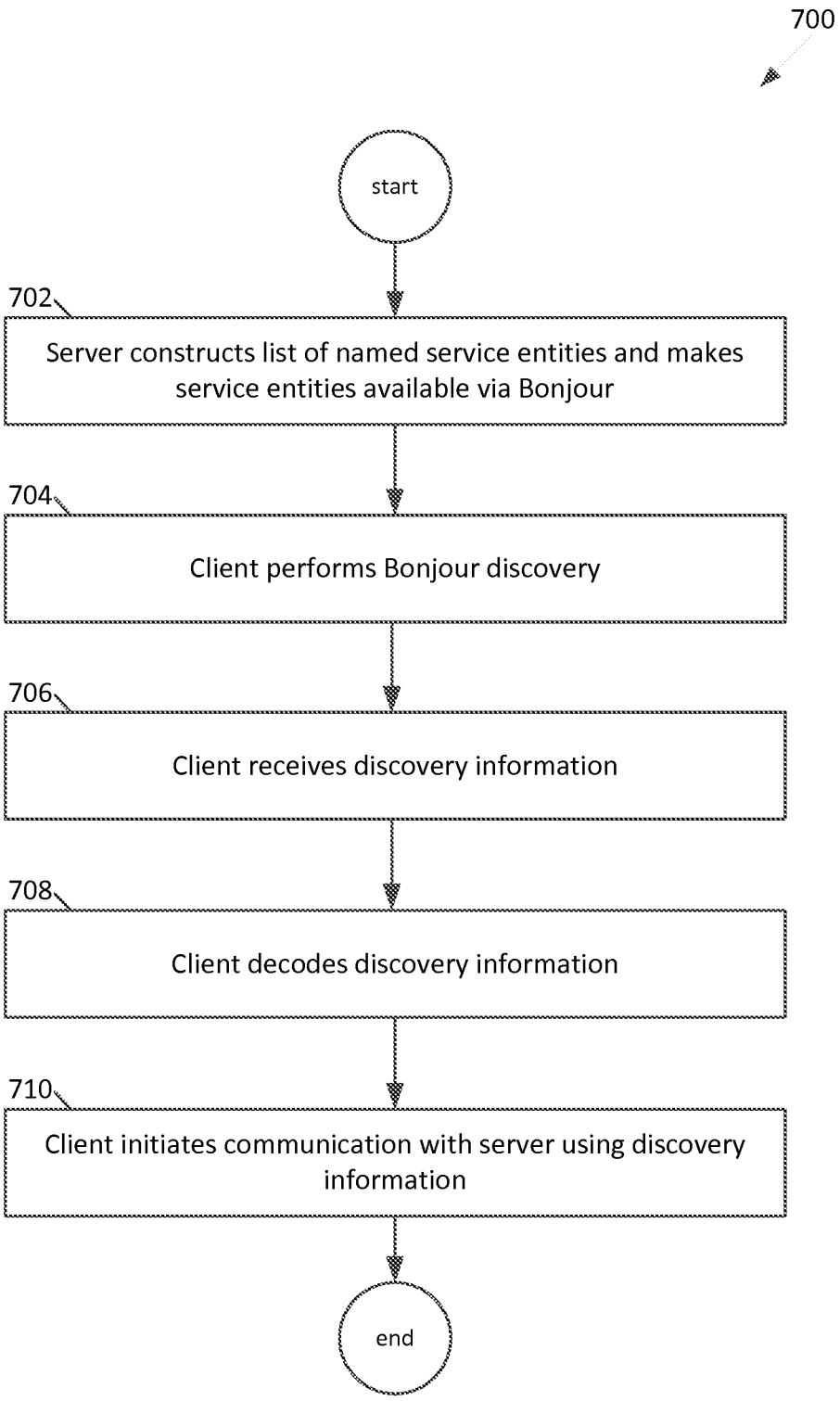

700
start
702
Server constructs list of named service entities and makes service entities available via Bonjour
704
Client performs Bonjour discovery
706
Client receives discovery information
708
Client decodes discovery information
710
Client initiates communication with server using discovery information
end

FIG. 7

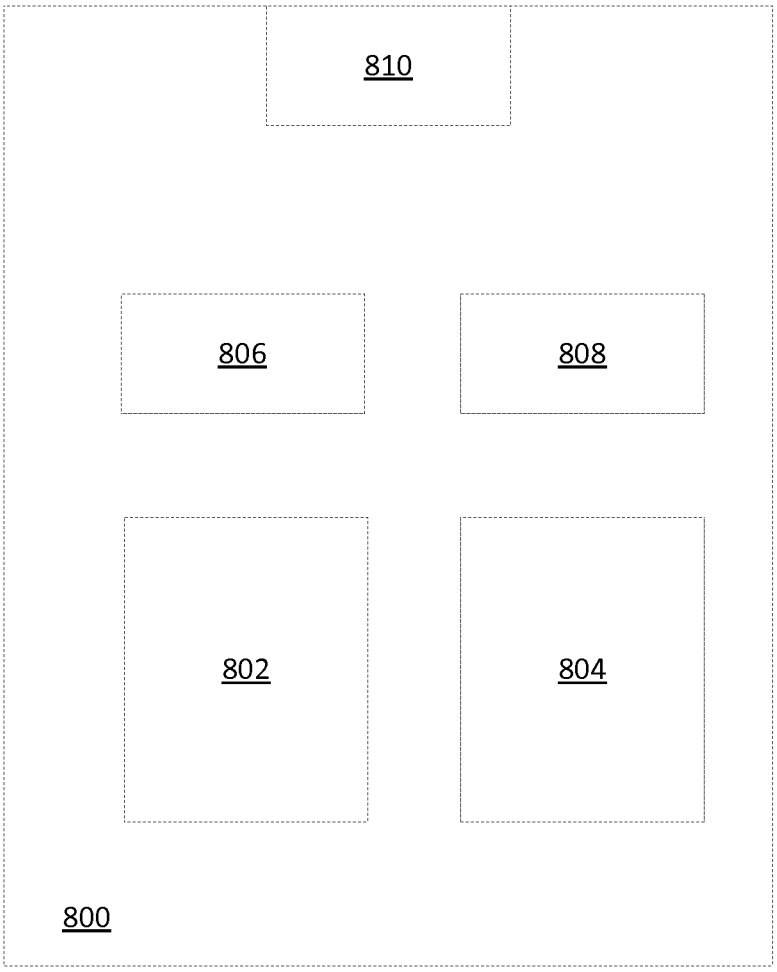


FIG. 8

DEVICE CENTRIC OR INTERACTIVE DISCOVERY

TECHNICAL FIELD

The present invention relates generally to communication between computing devices. More particularly, the present embodiments relate to discovery by one computing device of other computing devices, and/or establishment of communication between different computing devices.

BACKGROUND

Numerous useful features of portable computing devices rely on the ability of the devices to communicate information to and receive information from other computing devices. Wireless networking, in particular, provides portable computing devices with the ability to access information available on the Internet, send and receive messages to other users, send and receive a user's documents and information to and from other computing devices, and so on. Computing devices often use communication techniques such as cellular data, WiFi™, and the like to communicate with other devices. These communication techniques ordinarily require that an address, Uniform Resource Locator (URL), or other identifying information be known about the other device with which communication is to be established. These addresses are readily obtainable in some cases, e.g., for devices that have Domain Name Service (DNS) names, such as a web server accessible via the URL. However, there are many devices that do not have their own URLs or have URLs, but the URLs are not known to users who wish to access the devices. Even if a list of the available devices is available, there may be a large number of devices, and selecting the best one from a long list can be difficult. In other cases, devices do not have URLs, and are discovered using a protocol such as Bluetooth®.

For example, an Apple TV® device, available from Apple® Inc. of Cupertino, Calif., provides an interface from a computing device to a television. Mobile devices, such as smart phones, can use the Apple TV to display images on the television. However, establishing a connection between a mobile device and a wireless television devices (e.g., Apple TV or like), or wireless printer (e.g., using AirPrint® or the like) may require that the device user be registered in a certain way, which may not be the case in some environments such as classrooms. In another example, there are many devices, e.g., 20,000 or more, in an area such as an auditorium, arena, or the like. Identifying the device of a particular person can be difficult, because an attempt to connect to another device is likely to involve selecting the other device from a large list of devices.

SUMMARY

The present application describes various embodiments regarding techniques that can be used to enable a computing device to discover other nearby computing devices. A nearby computing device can be, for example, a device located within a distance sufficiently close to allow a person at the location of the first device to see, hear, touch, or otherwise be informed of the existence or identity of the nearby device. The discovery information can be used to establish communication with the discovered device via existing protocols such as HTTP, TCP/IP, and the like.

Embodiments described herein provide device discovery features by providing or transmitting discovery information from a "server" device via a short-range communication protocol such as Bonjour® (an implementation of the Zeroconf protocol available from Apple, Inc. as the Bonjour® protocol), Bluetooth®, Infrared Data Association (IrDA®), optical barcode display and recognition, or the like. Since the discovery information sent by the server can only be received within a limited range, only users who are located within that range of the server see the server as an available device on their own devices. The discovery information provided by the server can include one or more URL's (Uniform Resource Locators) that reference the server and/or its services, or other information that identifies the server or a service provided by the server. In one or more embodiments, the server device provides the discovery information in response to a user pressing a physical button on the device, or selecting a graphical user interface element in a user interface displayed on a screen of the server, or by otherwise interacting with the server.

In one or more embodiments, methods and apparatus to discover computing devices in a local area are provided. In one aspect, devices are discovered by receiving, by a first device, a request to provide discovery information, generating, by the first device, the discovery information, wherein the discovery information includes a communication address of the first device, and providing, by the first device, the discovery information using a short-range protocol that can be received only within a defined distance of the first device.

Embodiments can include one or more of the following features. Receiving the request to provide discovery information can include detecting physical interaction with the first device by a user. The physical interaction can include pressing a button located on the device. The short-range protocol can use optical image recognition, and generating the discovery information can include generating an image based upon the communication address of the first device, and providing the discovery information comprises displaying the image on a display of the first device. The short-range protocol can use near-field communication, and receiving a request to provide discovery information can include receiving a request to establish a near-field communication channel from a second device located in close proximity to the first device, generating the discovery information comprises generating near-field communication data that includes the communication address of the first device, and providing the discovery information comprises transmitting the discovery information to the second device via a near-field communication data exchange.

The short-range protocol can use Bluetooth-based communication, and receiving the request to provide discovery information can include detecting physical interaction with the first device by a user, generating the discovery information comprises generating data in a Bluetooth format, wherein the data includes the communication address of the first device, and providing the discovery information comprises transmitting the discovery information to the second device via Bluetooth without Bluetooth pairing between the first and second devices. The short-range protocol can use Bonjour-based communication, and generating the discovery information can include generating data in a Bonjour format, wherein the data includes the communication address of the first device in a Bonjour record, and providing the discovery information comprises transmitting the discovery information to the second device via the Bonjour protocol.

In another aspect, devices are discovered by receiving, by a second device, the discovery information, wherein the second device is located within the defined distance of the first device, extracting, by the second device, the communication address of the first device from the discovery information, and

initiating, by the second device, communication with the first device using the communication address and a communication protocol associated with the address.

Embodiments can include one or more of the following features. The short-range protocol can uses optical image recognition, and receiving the discovery information can include optically recognizing an image displayed on the first device, and extracting the communication address can include decoding the image and identifying the communication address and communication protocol based upon the decoded image. The short-range protocol can use near-field communication, and receiving the discovery information can include receiving near-field communication data from the first device, and extracting the communication address comprises decoding the communication address from the near-field communication data. The short-range protocol can use Bluetooth-based communication, receiving the discovery information can include receiving Bluetooth data from the first device without a pairing between the first and second devices, and extracting the communication address can include decoding the discovery information from the Bluetooth data. The short-range protocol can use Bonjour-based communication, and receiving the discovery information can include receiving Bonjour protocol data from the first device, and extracting the communication address comprises decoding the discovery information from the Bonjour protocol data.

In another aspect, devices are discovered by sending, from a client device, a request for discovery information to a server device located within a defined distance of the client device, receiving, at the client device, discovery information from the server device, extracting, at the client device, a communication address of the server device from the discovery information, and initiating communication with the server device using the communication address and a communication protocol associated with the address. The server device can receive a request to provide discovery information, generate the discovery information, wherein the discovery information includes a communication address of the server device, and provide the discovery information using a short-range protocol that can be received only within a defined distance of the server device.

BRIEF DESCRIPTION OF THE DRAWINGS

The included drawings are for illustrative purposes and serve only to provide examples of possible structures and arrangements for the disclosed inventive apparatuses and methods for providing portable computing devices. These drawings in no way limit any changes in form and detail that may be made to the invention by one skilled in the art without departing from the spirit and scope of the invention. The embodiments will be readily understood by the following detailed description in conjunction with the accompanying drawings, wherein like reference numerals designate like structural elements, and in which:

FIG. **1** is a representative diagram showing discovery of nearby devices in accordance with one or more embodiments.

FIG. **2** illustrates a device discovery process in accordance with one or more embodiments.

FIG. **3** illustrates a process of discovering nearby devices using a short-range optical protocol in accordance with one or more embodiments.

FIG. **4** illustrates a process of discovering nearby devices using an NFC-based protocol in accordance with one or more embodiments.

FIG. **5** illustrates a process of discovering nearby devices using a Bluetooth-based protocol in accordance with one or more embodiments.

FIG. **6** illustrates a process of discovering nearby devices using a Wide-Area Bonjour-based protocol in accordance with one or more embodiments.

FIG. **7** illustrates a process of encoding and extracting discovery information using a local Bonjour-based protocol in accordance with one or more embodiments.

FIG. **8** shows a system block diagram of computer system used to execute the software of an embodiment.

DETAILED DESCRIPTION

Representative applications of apparatuses and methods according to the presently described embodiments are provided in this section. These examples are being provided solely to add context and aid in the understanding of the described embodiments. It will thus be apparent to one skilled in the art that the presently described embodiments can be practiced without some or all of these specific details. In other instances, well known process steps have not been described in detail in order to avoid unnecessarily obscuring the presently described embodiments. Other applications are possible, such that the following examples should not be taken as limiting.

The following relates to a portable computing device such as a laptop computer, net book computer, tablet computer, etc. The portable computing device can include a multi-part housing having a top case and a bottom case joining at a reveal to form a base portion. The portable computing device can have an upper portion (or lid) that can house a display screen and other related components whereas the base portion can house various processors, drives, ports, battery, keyboard, touchpad and the like. The base portion can be formed of a multipart housing that can include top and bottom outer housing components each of which can be formed in a particular manner at an interface region such that the gap and offset between these outer housing components are not only reduced, but are also more consistent from device to device during the mass production of devices. These general subjects are set forth in greater detail below.

In one or more embodiments, a computing device can discover other nearby computing devices that have made discovery information accessible to the first computing device. A nearby computing device can be, for example, a device located within a distance sufficiently close to allow a person at the location of the first device to see, hear, touch, or otherwise be informed of the existence or identity of the nearby device. The discovery information can subsequently be used to establish communication with the discovered device via existing protocols such as HTTP, TCP/IP, and the like.

Embodiments described herein provide device discovery features by providing or transmitting discovery information from a "server" device via a short-range communication protocol such as Zero configuration networking (Zeroconf, implemented in devices available from Apple, Inc. as the Bonjour protocol), Bluetooth, IRDA, or the like. Bonjour provides a way to find devices with which to communicate. Bonjour does not itself transfer data communication packets from one device to another. Since the discovery information sent by the server can only be received within a limited range, only users who are located within that range of the server see the server as an available device on their own devices. The discovery information provided by the server can include one or more URL's (Uniform Resource Locators) that reference

the server and/or its services, or other information that identifies the server or a service provided by the server. In one or more embodiments, the server device provides the discovery information in response to a user pressing a physical button on the device, or selecting a graphical user interface element in a user interface displayed on a screen of the server, or by otherwise interacting with the server. The button or user interface element may be labeled "Discover Me," for example. Thus, when a user of a portable device presses the Discover Me operation on a server device such as a television interface device, a printer, a projector, or the like, the server device provides, e.g., transmits, discovery information, using a communication protocol or method that can only be received within a limited distance of the server device. Since the user is close enough to the device to touch it, the user's portable device is within range of the communication, and receives the discovery information, which can be displayed on the portable device and selected by the user to establish communication between the portable device and the server. In another embodiment, the server can provide the discovery information in response to detection of a proximity device or card, or detection of motion using a motion sensor similar to those used for interior or exterior lighting.

FIG. **1** is a representative diagram showing discovery of nearby devices in accordance with one or more embodiments. A server device **104** has a communication interface **112**, which can communicate, e.g., send and receive data, to and from another communication interface **132** of a client device **124**. The communication devices **112**, **132** can be, for example, transmitters and receivers used in protocols such as Bonjour, Zeroconf, Bluetooth, IrDA, Near-Field Communication (NFC), or the like. The communications devices **112**, **132** can also use optical image display and recognition, e.g., by displaying QR barcode images on the server device **104**, and using a camera or other optical lens-based detector to recognize the optical image on the client device **124**. The Bonjour protocol is ordinarily layered on top of IP (the Internet Protocol) in networking stacks.

A local area **102**, which can be, for example, a room, an auditorium, and outdoor space, or the like, has a defined size that is based upon a range of a communication protocol used by the server device **104**. The range is illustrated by the distance d in FIG. **1**, so that devices outside the local area are located at a distance greater than the range of the communication protocol. Although a single specific value of the distance d is not ordinarily known, there is ordinarily a maximum distance beyond which the light or other electromagnetic radiation emitted by the communication interface **112** of the server **104** is not detectable or discernible by the other communication interface **132** in another device, such as the client device **124**. Therefore, a defined distance d can be identified, at least as an upper maximum value of the communication range of the protocol used by the interfaces **112**, **132**. In other examples, d can be an average of two or more distances in a range of distances associated with the communication interfaces. For example, if the range of the NFC protocol associated with the communication interfaces **112**, **132**, e.g., by a specification or their manufacturer, is 8-10 cm, then the defined distance d can be any of 8 cm, 10 cm, the average of 8 and 10 cm, or any specified value greater than the protocol range, such as 20 cm.

As introduced above, the communication interfaces **112**, **132** use one or more particular protocols. The protocols that are or can be used are identified by protocol type values **114**, **134**. For example, if the Bonjour protocol is being used, then the protocol type would be a value associated with the Bonjour protocol. The server **104** includes discovery information **106**, which identifies the server. The discovery information **106** includes a server profile **108** that specifies details such as a name of the server, capabilities or characteristics of the server, services provided by the server, and the like. The discovery information **106** also includes a server address **110**, which is a network address at which the server or a service provided by the server can be reached, e.g., a URL, domain name address, IP address, Bonjour address, or other type of address associated with the protocol type **114**.

In one or more embodiments, the server device **104** provides, e.g., transmits or displays, the discovery information **106** using the communication interface **112** and the protocol specified by the protocol type **114**. The protocol type **114** can be included in the discovery information. The server **104** can provide the discovery information **106** using multiple protocols, e.g., by sending the discovery information **106** using each type of protocol in succession. For example, a device that provides visual output, e.g., an Apple TV, or a display on a scanner or printer, and also supports NFC can enable both optical and NFC discovery. In one embodiment, the server **104** sends the discovery information **106** automatically, e.g., periodically, at certain times, in response to certain events, or upon receiving a discovery request via the communication interface **112**. In another embodiment, the server **104** sends the discovery information **106** when a user touches the device, e.g., by pressing a button **118** labeled Discover Me on the device, or by other physical interaction with the device, such as touching the device with the client device **124**, speaking to the device **104**, and so on.

In one embodiment, when the server **104** provides or transmits the discovery information **106**, the communication interface **112** makes a representation **116** of the discovery information is made available for detection by other devices **124**. Devices within the defined range d of the server device **104**, such as the client device **124**, detect and receive the discovery information **116** via the client communication interface **132**, and construct a discovery information representation **126** that can be used to initiate and establish communication with the server **104**. The client device **124** can use the server address **130** in the received discovery information **124** to initiate or open a communication session or send a message to the server **104**, depending on the particular protocol to be used. In one example, the protocol to be used is specified in the received discovery information **126**. In another example, the protocol to be used is the same protocol on which the communication interface **132** received the discovery information **126**. The protocol to be used to initiate the communication can be, for example, HTTP, TCP, UDP, IP, WiFi, a cellular data protocol such as EDGE, UMTS, LTE, and so on. Thus, the discovery information **126** received by the client device **124** enables the client device to identify and communicate with the server device **104**. Authentication and other communication configuration can be performed as part of the subsequent establishment of communication between the server **104** and client **124**.

In one embodiment, the discovery information **116** is not detected or received by a second client device **140**, because a communication interface **142** in the second client device **140** is beyond the range, e.g., the defined distance d, of the protocol that server device **104** used to transmit or otherwise provide the discovery information **116**. For example, the second client device **140** may be located in a different room than the service device **104**, or in the same room but at a distance beyond that at which the signal produced by the communication interface **112** can be detected. In another example, devices, including those that are within the defined range of the server device **104**, such as the client device **124**, do not

receive the discovery information **116** if there is an obstruction, such as a physical object, located between the server **104** and the client **124** that interferes with the signal, or other form of interference with the signal. However, since users of the client device **124** can be located near the server device **104**, users are likely to be able to see the server device **104** and identify and remove such obstructions, or physically move the server **104** and/or client **124** as appropriate to reduce the interference.

FIG. **2** illustrates a device discovery process **200** in accordance with one or more embodiments. Process **200** can be implemented as, for example, computer program code encoded on a computer readable medium and executable by a processor of a computer system, by processors of two or more computer systems. In on example, as shown in FIG. **2**, the device discovery process **200** can broadcast information that can be detected by clients to discover the server. The process begins at block **202**, in which a user in close proximity of a first device, such as a server **104**, interacts with the device, e.g., by physically pressing a button **118** on the device. The physical user interaction is one way to begin the discovery process, but other ways are possible as well. Therefore, block **202** is optional, and the process can begin at block **204**, which can be executed in response to an event such as another type of discovery request received by a different communication protocol, a query received from a second device **124**, or by a periodic timer, or other type of event.

At block **204**, the first device generates discovery information **106**, e.g., by storing the server profile **108** and server address **110** in the discovery information **106**. The server address **110** can be an address in the format of a service protocol, such as HTTP, TCP/IP, or the like, via which the server receives communication requesting its services, such as receiving documents to print, receiving video to display, transmitting image data, and the like. The service protocol can be determined by other devices from the address **110**, or the service protocol can be included in the discovery information **106**. At block **206**, the first device transmits, broadcasts, or otherwise provides the discovery information **116** via a short-range protocol such as Bonjour, Bluetooth, NFC, QR images, and so on, as introduced above. A second device within receiving range of the first device detects and receives the discovery information **116** to create discovery information **126** in a memory of the second device **124** at block **208**. In one aspect, the second device **124** is located within a defined distance of the first device, such as at a distance less than a maximum range of the communication protocol used to transmit the discovery information **116**. In one aspect, devices beyond the range of the communication protocol do not detect the discovery information **116**, so the dissemination of the discovery information **116** is limited to devices within the local area **102**. In one or more other embodiments, instead of broadcasting the discovery information, the first device receives a query from the second device **124** at block **202**, and sends the discovery information at block **204** to the second device **245** in response to the query.

At block **210**, the second device **124** extracts the first device's communication address **130** from the received discovery information **126**. Then, at block **212**, the second device **124** initiates communication with the first device **104** using the communication address **130** and the protocol associated with the communication address **130**, or a protocol specified in the discovery information **126**. In one example, the second device **124** can determine whether to initiate communication with the first device **104** based upon the server profile data **128** received by the second device **124**. For example, if the profile data **128** indicates that the first device **104** (i.e., the server) does not provide the service that the second device **124** is searching for, then the second device **124** need not initiate a connection to the second device **104**. The second device **124** can decide not to initiate a connection for other reasons as well, e.g., if the response time from the first device **104** is greater than a threshold, or if the protocol of the server address **130** is not supported by the communication interface **132** of the second device **124**. Once communication with the second device has been initiated, the process **200** ends.

FIG. **3** illustrates a process **300** of discovering nearby devices using a short-range optical protocol in accordance with one or more embodiments. Process **300** can be implemented as, for example, computer program code encoded on a computer readable medium and executable by a processor of a computer system. The optical protocol can, for example, display a Quick Response code (QR) code that represents the discovery information on the server, and use optical image recognition on the client to decode the QR barcode images. This, in an optical protocol, the discovery information includes an image based upon the communication address of the first device. The first device provides the discovery information at by displaying the image on a display, such as an LCD or CRT screen located on or near the first device. Printers and laptop computers, for example, have screens on which the image can be displayed. The QR codes can be displayed on an idle screen that appears when the printer's user interface has been inactive for a period of time, or when selected via a menu interface, or when a Discover Me or other button **118** is pressed on the front of the device (block **302**). A QR code can also be displayed on a kiosk computer used for Podcast Capture in a lecture room. In one aspect, displaying the data needed for a QR code supporting device discovery may place a requirement on the minimum screen resolution. For example, a Version 10 QR code can have 57 by 57 pixels, and can convey **395** alphanumeric characters, which are expected to be sufficient to represent multiple instance of the discovery information. The QR code, e.g., a barcode image, is displayed on a screen or other display device of the first device (block **304**).

The second device can receive the QR-format discovery information by optically recognizing an image displayed on the first device using a camera and lens with QR image scanning software or hardware (block **306**). The QR-based discovery protocol can be used by a computer that has an integrated camera, such as a laptop or desktop computer, including computers with detachable screens that can be waved in from the of the computer, so that the user need not wave the computer in front of the device. The discovery information can be extracted by decoding the information in the recognized image and retrieving the communication address and communication protocol from that recognized information (block **308**). The second device then initiates communication with the first device using the communication address and protocol extracted from the image (block **310**), and the process ends.

FIG. **4** illustrates a process **400** of discovering nearby devices using an NFC-based protocol in accordance with one or more embodiments. Process **400** can be implemented as, for example, computer program code encoded on a computer readable medium and executable by a processor of a computer system. NFC enables devices to communicate via radio when the devices are touched together or brought into close proximity of each other, e.g., within a few centimeters. In discovery via NFC, the discovery process can be initiated at the server, e.g., an Apple TV, printer, scanner, or computer, when the server receives a request to provide discovery infor-

mation (block **402**), either from the client **124** or from a user. In the case of a user request, the request can be a press of a button **118** on the server, or other type of user-initiated request, as described above. The client device can be, for example, an iPhone®, iPad®, iPod®, computer, or other device offering the client device discovery information to locate the service device for AirPrint™, AirPlay®, or other Bonjour-mediated discovery methods. In one or more embodiment, a user sets the device to find an AirPrint, AirPlay, or other service, and then waves the device near, or taps with the device, the server to initiate the discovery.

In one aspect, discovery information is not transmitted via NFC until an initial request has been received, because the NFC protocol model involves an initial request from a client to establish a connection, such as a client bumping their device against the server device. The discovery information is then sent to the requesting client as data in a NFC data exchange (block **404**). The client receives the near-field communication data from the first device (block **406**), and decodes the communication address from the near-field communication data (block **408**). The client then initiates communication with the server using the communication address and associated protocol (block **410**).

In one example, NFC discovery and the Discover Me button **118** can be used in a server room environment. Server computers are often mounted in rack hardware, with many server devices concentrated into a small space. Tracking the identity of specific server devices can be cumbersome or challenging in such an environment. If a device's network identity or name is changed, then existing physical labels that list the previous identity or name are incorrect, and should be changed, which involves manually updating each label. Administrators can press a Discover Me button **118** on the device they wish to discover, thereby easily identifying a device for which only the physical location is known.

FIG. **5** illustrates a process **500** of discovering nearby devices using a Bluetooth-based protocol in accordance with one or more embodiments. Process **500** can be implemented as, for example, computer program code encoded on a computer readable medium and executable by a processor of a computer system. In Bluetooth-based discovery, the discovery process can begin when the client requests discovery information of a server (block **502**). In one aspect, discovery information is not sent until a client request is received, since Bluetooth has a greater range than some other communication protocols, and the discovery information is more likely to be intercepted by other users at greater distances who are not close enough to the server device to use it, and/or are less likely to be authorized to use the server device. The discovery information, including the communication address of the first device and/or a protocol to be used for subsequent communication between the client and server. The discovery information can be encoded in a Bluetooth format, e.g., in an EIR record, and transmitted to the second device via Bluetooth (block **504**). In one aspect, the Bluetooth communication is performed without requiring that the first and second devices be paired. Avoiding the Bluetooth pairing process, in which the user performs steps that can involve providing a security code, can enhance the user experience because the discovery process can proceed quickly without additional user intervention.

The client device receives the Bluetooth data from the service device without a pairing (block **506**), and extracts the communication address by decoding the discovery information from the Bluetooth data (block **508**), e.g., by examining the EIR record in the received Bluetooth data and detecting the extra information in the EIR record, which includes the communication address and protocol. In one aspect, Bluetooth pairing is not required because the discovery protocol is used to identify but not communicate with the server device. In this aspect, communication with the server device is done via other protocols such as TCP/IP, HTTP, and so on. In another aspect, the discovery information can include an indication that the discoverer (e.g., client) can use Bluetooth to contact the discovered device (e.g., server) after establishing a pairing. In either aspect, the client initiates communication with the server using the determined protocol (block **510**). In one example, a device that has a Discover Me button **118** or other demand-based discovery protocol can provide Bluetooth, NFC, and/or optical discovery protocols when discovery is requested, e.g., when the Discover Me button **118** is pressed.

FIG. **6** illustrates a process **600** of discovering nearby devices using a Wide-Area Bonjour-based protocol in accordance with one or more embodiments. Process **600** can be implemented as, for example, computer program code encoded on a computer readable medium and executable by a processor of a computer system. A server that uses Bonjour can be given human-readable names for its services. A list of named service entities can be constructed to represent the discoverable services. Each named service entity includes both a service name and the human-readable name for the service. For example, 'http' is the name for HTTP web services. A server that uses Bonjour can be configured to register its services with a Wide-Area Bonjour server at block **602**. Process **600** can be used by a server that is configured to register its services with a Wide-Area Bonjour server. In this Wide-Area Bonjour case, each named service entity need only include the service name and human-readable name. An example of a named service entity representing a web page is:

http._tcp PTR Employee Information Page._http._tcp.apple.com

A client discovers the named service entity by querying the Wide-Area Bonjour server at block **604** for available services. Upon receiving a response from the Wide Area server, the client extracts this named service entity at block **606**. The client determines if the service is of interest by examining the encoded service name, e.g., 'http' in this example. If the client is interested in the service, the client then performs a standard Bonjour Service Resolution at block **608** to resolve the service entity, e.g., 'Employee Information Page._http._tcp.apple.com' in this example, into the information needed to access the service server, e.g., a communication address and protocol type, and communicates with the server using that information at block **610**.

In one aspect, implementers of this discovery process may mutually agree to employ one or more methods of compression when encoding named service entities. This compression may include, but not be limited to, abbreviations, tokenizations, and other methods known to one of ordinary skill in the art.

FIG. **7** illustrates a process **700** of encoding and extracting discovery information using a local Bonjour-based protocol in accordance with one or more embodiments. Process **700** can be implemented as, for example, computer program code encoded on a computer readable medium and executable by a processor of a computer system. As with process **600**, a server that uses Bonjour can be given human-readable names for its services. At block **702**, the server can construct a list of named service entities to represent the discoverable services, and makes the named service entities available via the Bonjour protocol. Each named service entity includes both a service name and the human-readable name for the service. For example, 'http' is the name for HTTP web services. Process

700 is meant to be performed by a server that does not register its services with a Wide-Area Bonjour server. Each named service entity constructed at block **702** includes the information ordinarily conveyed via Bonjour discovery. This conveyed information ordinarily includes a network address, a network port, and possibly additional information. Some protocols use additional information to qualify the exact service. For example, a web server can require the server-relative path to locate the web page. The server encodes this information in a manner mutually agreed on by implementers of this discovery process. An example for the web page described above with reference to FIG. **6** is:

_http._tcp SRV 10.11.12.13 80 path=/

The client performs Bonjour discovery, e.g., by sending discovery requests to one or more hosts on the network, at block **704**. The client receives discovery information from the hosts(s) at block **706**. The client decodes the discovery information at block **708**. Upon decoding the discovery information, the client has the information it would receive after the completion of a Bonjour Service Resolution. The client then proceeds to contact the server using the decoded discovery information, such as a communication address and protocol, at block **710**.

To set up a Bonjour service, the address of the server for that service name can be specified in a Bonjour service configuration (e.g., a configuration file) at block **602** for Wide-Area Bonjour, or at block **702** for local Bonjour. The server address and a path on the server can be associated with the service name in the file or registration. The server address, e.g., neinfo.example.com, is specified as a SRV record, and the path on the server, e.g., "/", is specified as a TXT record. A lookup can then be performed using the service name to find the server address previously associated with the server by the service configuration (block **608**). For example, in Bonjour infrastructure (e.g., Wide Area) mode, the server may transmit the service name Employee Information Page-._http._tcp in the discovery information **116**. The second device **124** can receive that service name and use it to look up the associated information described above, such as the server address and path on the server. In non-infrastructure (i.e., ad-hoc/local) mode, there is no lookup service, so the server sends the service name and the associated information in the discovery information **116**, e.g., the server address **110** and the path on the server, which can be included in the server profile **108** (block **702**). Once the client has extracted the communication address from the discovery information at block **708**, the client initiates communication with the server using that communication address and the associated protocol at block **710** for local Bonjour, or block **608** for Wide Area Bonjour).

FIG. **8** shows a system block diagram of computer system **800** used to execute the software of an embodiment. Computer system **800** includes subsystems such as a central processor **802**, system memory **804**, fixed storage **806** (e.g., hard drive), removable storage **808** (e.g., FLASH), and network interface **810**. The central processor **802**, for example, can execute computer program code (e.g., an operating system) to implement the invention. An operating system is normally, but not necessarily, resident in the system memory **804** during its execution. Other computer systems suitable for use with the invention may include additional or fewer subsystems. For example, another computer system could include more than one processor **802** (i.e., a multi-processor system) or a cache memory.

Although the foregoing invention has been described in detail by way of illustration and example for purposes of clarity and understanding, it will be recognized that the above described invention may be embodied in numerous other specific variations and embodiments without departing from the spirit or essential characteristics of the invention. Certain changes and modifications may be practiced, and it is understood that the invention is not to be limited by the foregoing details, but rather is to be defined by the scope of the appended claims.

What is claimed is:

1. A method, comprising:

at a first device:

receiving a request to provide discovery information;

generating the discovery information, wherein the discovery information includes a communication address of the first device, and the communication address is associated with a first protocol;

identifying at least a second protocol and a third protocol available to the first device;

transmitting the discovery information to a second device using both the second and the third protocols, wherein:

the discovery information can be received by the second device only when the second device is located within an operating distance of the first device,

the second and third protocols are short-range protocols, and

the discovery information is transmitted to the second device without requiring the first device and the second device to be paired; and

establishing a communication session with the second device, wherein the communication session is initiated by the second device using the communication address and the first protocol.

2. The method of claim **1**, wherein receiving the request to provide the discovery information comprises detecting a physical interaction with the first device by a user, and the physical interaction comprises the user pressing a button located on the first device.

3. The method of claim **1**, wherein the discovery information is transmitted to the second device using each of the second protocol and the third protocol in succession.

4. The method of claim **1**, wherein:

the second protocol differs from the third protocol, and

the discovery information is encoded in an Extended Inquiry Response (EIR) record.

5. The method of claim **1**, wherein the communication address of the first device is extracted from the discovery information by the second device.

6. The method of claim **5**, wherein:

the second protocol differs from the third protocol, and

the communication address is extracted from the discovery information by examining an Extended Inquiry Response (EIR) record by the second device.

7. The method of claim **1**, wherein the discovery information includes profile data associated with the first device.

8. The method of claim **1**, wherein the first protocol used to establish the communication session is specified in the discovery information.

9. A system, comprising:

a first device and a second device, wherein the first device comprises a first processor configured to cause the first device to:

receive a request to provide discovery information;

generate the discovery information, wherein the discovery information includes a communication address of the first device, and the communication address is associated with a first protocol;

identify at least a second protocol and a third protocol available to the first device;

transmit the discovery information to the second device using both the second and the third protocols, wherein:

the discovery information can be received by the second device only when located within an operating distance of the first device,

the second and third protocols are short-range protocols, and

the discovery information is transmitted to the second device without requiring the first device and the second device to be paired; and

establish a communication session with the second device, wherein the communication session is initiated by the second device using the communication address and the first protocol.

10. The system of claim **9**, wherein, to receive the request, the first processor further causes the first device to:

detect a physical interaction with the first device by a user.

11. The system of claim **9**, wherein:

the second device comprises a second processor configured to cause the second device to:

extract the communication address of the first device from the discovery information; and

initiate the communication session with the first device using the communication address and the first protocol.

12. The system of claim **11**, wherein:

the second protocol differs from the third protocol, and

the second processor further causes the second device to:

extract the communication address from the discovery information by examining an Extended Inquiry Response (EIR) record.

13. The system of claim **9**, wherein:

the second protocol differs from the third protocol, and

the discovery information is encoded in an Extended Inquiry Response (EIR) record.

14. The system of claim **9**, wherein the discovery information includes profile data associated with the first device.

15. The system of claim **9**, wherein the first protocol used to establish the communication session is specified in the discovery information.

16. A non-transitory computer readable medium configured to store instructions that, when executed by a processor included in a client device, cause the client device to carry out steps that include:

transmitting, to a server device located within an operating distance of the client device, a request for discovery information, wherein the discovery information includes a communication address of the server device, and the communication address is associated with a first protocol;

receiving the discovery information from the server device, wherein:

the discovery information is received using both a second protocol and a third protocol available to the server device, and

the discovery information is received without requiring the server device and the client device to be paired;

extracting the communication address of the server device from the discovery information; and

initiating a communication session with the server device using the communication address and the first protocol.

17. The non-transitory computer readable medium of claim **16**, wherein:

the discovery information is generated by the server device.

18. The non-transitory computer readable medium of claim **16**, wherein the first protocol used to initiate the communication session is specified in the discovery information.

19. The non-transitory computer readable medium of claim **16**, wherein the discovery information includes profile data associated with the server device.

20. The non-transitory computer readable medium of claim **16**, wherein the steps further include:

determining whether to initiate the communication session with the server device based on profile data associated with the server device.

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